Collaborating on “Integrated Smart Grid” Demonstrations

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India Case Study: Areas for Collaboration

- Developing Frameworks for Capturing Distributed Energy Resource/Renewable Energy Net Benefits, Using Smart Grid Tools and Methods

- DER/RE Valuation Frameworks and Planning Protocols

- Evolving a 3.0 “Integrated Operating Grid” -- EPRI

- New “Policy/Regulatory Eco-System” to Support DER Investments in parity with traditional bulk supplies

India's "Sea Change": Smart Grid Vision and Roadmap

- **A New Vision for a Changing Energy Landscape:** Proliferating Distributed and Renewable Resources creating new points of power injection and variability "at the edge";
- **Roadmap Shift:** From highly, centralized, target-driven, supply-push approach to combining decentralized elements and re-orienting to "customer/demand driven" strategy using smart technologies;
- **New Market Drivers:** RE, DER, Smart City Policies; Technology Advancements; Customer Energy Access, Needs and Choice;
- **Opportunities Growing:** Universal Energy Access, Electricity Reliability and Resiliency, Greenhouse Gas Emissions Reduction and Environmental Quality, Sustainable Economic Growth and Development;
- **Changing Value Proposition of RE/DER:** Widening range of applications; New role for clean DE as "Customer Solutions" and to support Grid and Market;
- **Arising Need for a New Distribution System Planning, Investment and Control Model:** Smart Grid Challenge to Move from Variability to Reliability and Long-Term Customer Value (VER, Unpredictable D-side Resources)

Net Benefits of DER to Customers, Grid and Society

- **Distributed and Demand-Side Resources can offer Net Benefits to Customers, Grid and Society;**
- **DER:** DER are electricity sources that are: (1) Interconnected to the grid in an approved manner at or below IEEE medium voltage; and also can (2) Generate electricity using any primary fuel source; or (3) Store energy and supply that electricity to the grid; or (4) Involve load changes undertaken by end-use customers in response to price and other inducement; Disruptive or Net Benefits?
- **Potential Consumer Benefits** – Reduce electric bills, increase energy independence, increase reliability/resiliency, provide clean energy options;
- **Potential Grid Benefits** – Voltage and power quality, conservation voltage reduction, grid reliability/resiliency, equipment life extension, reduced energy prices, increased asset utilization and system efficiency, load management;
- **Potential Societal Benefits** – Grid resiliency/reliability, Environmental, Energy Efficiency, Customer Service Options/Choices;
- **Weigh Benefits against Costs in terms of DER Impacts (**increasing volumes, diversity/characteristics, locations) **on Distribution System** (voltage regulation, voltage support, protection coordination, energy losses, energy consumption, capacity, reliability); **Impacts on Bulk Power System** (Resource Adequacy/Expansion; Resource Flexibility; Transmission Expansion/Performance; Operational Scheduling/Balancing) and **Integration Costs.**

Capturing DER/RE Benefits with Smart Grid Technologies

- **Smart Grid Potential:** Create conditions at Utility Distribution Systems Level for new “electric resources” to achieve policy objectives;

- **Smart Grid Potential:** Expand and modernize electrification from source to sink; Enable two-way power, information and transactional flows; Allow customers to benefit from dynamic pricing and distributed energy;

- **Smart Grid can Increase Market Value and Support Widespread Use of DER,** combining power engineering, sensing and monitoring technology, information and communications technology with legacy elements of T&D;

- **Smart Technologies enable visibility, predictability, interoperability, integration, forecasting, flexibility and event control to generation, delivery and end use** to integrate intermittent renewables and distributed resources, reduce peak demand and outages, increase system efficiencies and asset utilization, manage and optimize distributed resources, deploy intelligent energy management to close the supply gap.

New Paradigm for an “Integrated Grid”

- **India Smart Grid Vision reflects a New Paradigm:** Expanded electricity value chain boundaries; Integration of new resources and technologies (decentralized elements/DER); New Market Players – “Prosumers,” Third Parties in electricity market; and need for regulatory interventions to change current paradigm and utility business model to achieve policy objectives, while maintaining reliability, safety and affordability; **New Operating Parameters, Players and Structures**
- **“Integrated Grid”:** Take fully into account and value DER in Utility Planning, Investments, Operations and Trading; Grid Design to increase the independence, flexibility and intelligence for optimization of energy use and management within local energy networks (building, community and distribution system levels) and to integrate local energy resources (supply and demand assets) into the Smart Grid;
- **Interactive, Flexible and Innovative Grid to “Leap Forward”:** Highly flexible, configurable and interactive networks of utility, customer and third-party applications; market data, price signals and transactions; “System of Systems” operations for DER integration and load-side management; All electricity resources treated as primary resources.

New Utility Distribution System Model

- **Lessons from California's Evolving New "Utility Distribution System Paradigm":** Respond to dynamically changing market conditions and manage customer-side resources using smart technologies (Transmission System-like functions to Manage Distribution Operations):
- **Maintaining reliable distribution system operation with two-way, multi-point, reversible power flows with increasing volume and diversity of distributed resources** (voltage monitoring, telemetry and real-time control);
- **Integrating and Balancing distributed resources and load to shape load profile and peak demand and to enable "multifunction" DER to provide services to bulk power system; Reducing need for transmission and generation investments in bulk system flexibility, ramping and reliability; Developing local energy markets;**
- **Achieving functional control of DER for real-time balancing and flexibility and services such as reactive power and frequency control to local or bulk grid; modelling and forecasting load and DER growth;**

New Utility Distribution System Model

- **Defining and Managing the Boundary between Transmission and Distribution** to reliably and optimally operate the whole power system;
- **Addressing changing nature and characteristics of new "resources"** (Onsite RE, DG, CHP, DSM, ES, EV, DR, EE) **and changing nature of customers** (emerging "prosumers" and cultivating demand elasticity);
- **CA and NY evolving a New Regulatory Framework** to achieve Policy Objectives and Align Utility Financial Interests to Create Long-Term Customer Value; Regulatory Innovations designed to value system-based investments and operation protocols that can drive distribution utility efficiency and innovation;
- **New "Policy Eco-System" to support investment in interoperability and integration on a power system-wide scale, with particular focus on Distribution System Changes, to standardize the use of distributed and demand-side resources as part of overall power system planning, grid operation and power market trading.**

Regulatory, Technical and Business Innovations to Capture DER Benefits

- **Objectives for a Distributed Energy Future:** (1) Align Utility financial interests and incentives to create long-term customer value; (2) Shift from meeting peak capacity and "building more to profit" to load profiling and optimizing investments; from measuring megawatts sold to measuring value creation; from selling commodities to providing "infrastructure as a service;"
- **Address Traditional Assumptions:** (1) Little role for customers to play in addressing system needs; and (2) Centralized generation and bulk transmission invariably yield cost-effective results;
- **"Interoperability" to Standardize Use of DER throughout Electricity Value Chain through Smart Grid Design; Information Access and Valuation Methods; and Regulatory Innovations;**
- **Smart Architectural Design to:** (1) **Advance interoperability and integration "end to end"** from "source to sink;" and (2) **Evolve highly flexible, configurable and interactive networks** (3.0 Operating Grid to realize DER benefits through cost-effective Distribution System level architecture, functions, interactive platforms and delivery systems;
- **Valuation Methods/Tools to:** (1) Measure consistently full range of DER/Microgrid costs/benefits; (2) Integrate DER into Utility Planning, Procurement and Investment processes; and (3) Optimize mix of centralized and distributed resources;
- **New regulatory and social compact**: Change incentives of traditional ratemaking, cost of recovery, rate design to make utility decision-making indifferent to ownership and focused on achieving the most cost-effective solutions; shape new Utility Business and Service Delivery Models
- **Phased Approach to Change Corresponding to DER Market Penetration: Interconnection** (Physical Capability, Reliable Operation); **Integration** (Regulatory/Market Structures for DER Integration into Utility Planning, Operations and Trading); and **Intelligent Interconnectivity** (Cyber, Hierarchical Grid Agents of Control/Interoperability)

DER Valuation and Distribution Resources Planning

- **California mandated IOUs to file Distribution Resource Plans meeting requirements of the CA Public Utility Commission's Guidance:**
- **Distribution Integration Capacity and Locational Value Analysis:** Use of uniform, consistent and verifiable Integration Capacity and Optimal Location Benefit methodologies and development of DER Growth Scenarios (Circuit to Feeders);
- **Proposed Demonstrations and Deployment**: Test and validate dynamic "hosting capability" and optimal local benefit methodologies to determine distribution system constraints and identify DER locational net benefits; Evaluate Distribution Operations at High Penetrations of DERs; Pilot DER dispatch to meet system reliability/resiliency needs (Microgrids);
- **Data Access, Transparency and Sharing:** Propose Policy on Data Sharing; Procedures/Protections for Data Sharing; Grid Conditions Data and Smart Meters; DER own/operator Data;

Proactive DER Planning

- **Evaluate Barriers to DER Development:** (1) Interconnection into Distribution Grid; (2) Limitations on ability of DER to provide benefits; (3) Distribution System Operational and Infrastructure Capability to enable DER-provided value (needed investment in advanced technology such as protection and control systems, telecommunications and sensing);
- **Proactive DER Planning Process*:** (1) Load and DER adoption Forecasting; Determine Net Load Profile; (2) Modelling to determine T&D Grid Impacts from load/DER Growth; (3) Modelling to determine Bulk Power Impacts, including distribution level impacts; (4) Determine Net Benefits of DER based on location, timing and services (Compare with traditional investments and calculate financial and rate impacts of DER deployment); (5) Craft appropriate policies (tariffs, contracts, competitive solicitations) to source DER at right place and time; and (5) Develop overall utility DER strategy, model business model and modify utility operations to support cost-effective DER integration. *Black and Veatch, "Planning the Distributed Energy Future"* (February, 2016)

DER Benefit/Cost Framework

- **Developing Common Evaluation Methodology** to compare and monetize the benefits and costs relating to impacts of DER adoption at low and high levels on distribution systems with different loads and design and serving different electricity demands;
- **Defining Core Assumptions** (market conditions, DER adoption and scenario definitions), **Identifying DER Characteristics that Drive System Impacts and Methodological Components** (Distribution System impacts attributable to interconnected DER; Bulk System Impacts; Benefit-Cost Analysis);
- **Monetizing DER Impacts to Determine Net Benefits; Categorizing Impacts relating to Utility-Cost Function** (utility revenue requirements) and **External Elements** (societal benefits);
- **Comparing DER solutions to mitigate adverse impacts or to improve system performance with traditional investments; Develop strategies to maximize net benefits of DER;**
- **Applying existing/new simulation modelling and analytical tools*** (*EPRI, "Integrated Grid: A Benefit-Cost Framework"* (2015)

Demonstrations to Incent Investments that Support "Integrated Grid Design"

- **New Regulatory Framework to support Investment into a 3.0 "Integrated Grid"** to meet digital age, integration of RE/DE;
- **"Smart Grid" Transactive Features:** High levels of security, power quality, reliability and availability; manage two-way power, information and transactional flows to create an automated widely distributed energy delivery network;
- **Open Source Architecture, Standards and Protocols and Configurations** to achieve interoperability, integration and flexibility and to facilitate competitive transactions in support of DER;
- **Components:** AMI; OT/IT integration; Advanced Distribution Management System; Distributed Energy Resource Management System (sensors, communication and computational ability/modelling, simulation, analytical and diagnostic tools and methods for proactive distribution control model);
- **Elements of Smart Grid Demonstrations:** Application of critical integration technologies and standards; integration of multiple distributed resource types; incorporation of dynamic rates and other approaches for connecting retail customers with wholesale conditions; DER integration into system planning/operations.

Principles for Changing the Rules to Capture DER Benefits

- **Realign Utility Incentives to Deliver Safety, Reliability and Affordability and Create Long-Term Customer Value, regardless of ownership and service models that develop in marketplace; Achieve Public Policy Objectives;**
- **Overcome Structural Biases of Legacy System:** Limits of traditional cost of service and rate of return regulations that encourage overinvestment in capital spending, with capital spending tied to unmanaged peak loads;
- **Align utility earnings opportunities with customer value,** increasing deployment of non-regulated third-party capital, stimulating price-responsive customer behavior and supporting utility reliance on DER as an integral grid resource;
- **Reform traditional economic regulation** to achieve more efficient allocation between capital and operating expenses and to incent continuous improvement and innovation;
- **Develop a results-based model,** to shift regulatory focus from the reasonableness of historically incurred costs to pursuit of long-term customer value (Performance Metrics linked to Policy Objectives – Customer Satisfaction; Resiliency/Energy Assurance; System Efficiencies and Operational Effectiveness; Energy Efficiency/Environment);
- **Provide Accurate and Appropriate Value Signals,** reflecting long-term avoided costs and real-time value-supply, to furnish the information and compensation to support market activity and consumer engagement;
- **Assure fairness and equity to all customers, whether or not they can install DER.**

Lessons from NY REV Reforms

- **In "Reforming Energy Vision" (REV), NY developing a "distributed system platform" (DSP) to allow DER to be tracked, forecasted and traded within the distribution system;**
- **Retail Platform will be planned, designed and operated to enable Power System to serve State Policy Goals:** (1) Customer knowledge and tools to support effective energy management; (2) Market animation and leveraging of ratepayer contributions; (3) System-wide efficiency; (4) Fuel and resource diversity; (5) System reliability and resiliency; and (6) Reduction of Carbon Emission;
- **Envisioned Elements:** Retail-level energy markets and markets for new products and services; Market-based DER contribution to system balancing, flexibility and reliability; Demand Management on day-ahead and real-time basis; Expanded access to system information by customers and DER providers to calculate time-based and location-based values; Demand-response tariffs, including tariffs for storage; regulatory oversight of DER providers and limits on ownership of DERs by distribution utilities.

NY REV Reforms

- **NY REV is reforming the role of Utility Distribution Companies into "Distributed Systems Providers"** responsible for establishing and managing the retail platforms to achieve State energy policy objectives, while maintaining system reliability;
- **Utility DSPs will source DER products and services through competitive processes,** taking the form of regulated tariffs, automated real-time day-ahead markets for day-to-day optimization of distribution circuits, and solicitations to address system needs;
- **DSPs to manage and coordinate wide range of DER to place more efficient demands on bulk power system, while reducing the need for costly distribution system capital investments;**
- **Reorienting Utility Business Model into an "Infrastructure as Service"/Multi-sided Platform,** providing comprehensive customer service that includes DER;
- **DSP aims to foster broad market activity that monetizes system and social values** (currently unaccounted for in the utility cost of service or accounted for separately), by enabling active customer and third party engagement that is aligned with the wholesale and bulk power system;

NY REV Reforms

- **Changing rate designs and pricing methods to provide truer costing of electricity, offer increased granularity in the provision of electricity services, and allow customers to align investments in DER more efficiently and economically;**
- **Utility Business Model Reforms include greater use of performance incentives (**Earnings Impact Mechanisms), **opportunities for market-based earnings and removing disincentives to using cost-effective third-party and operating resources** (Earn income and rate of return from provision of grid services from non-utility owned DERS; Tying earnings sharing mechanisms to outcome indices);
- **Incremental ratemaking reforms to Utility Revenue Model,** moving towards rates based on marginal cost to system attributable to a customer's energy usage and supporting the multi-sided retail platform;
- **Provide dynamic price signals and rate design that reflects the value of grid service to customers and value of DER to grid** (based on DER timing, location, flexibility, predictability and controllability).

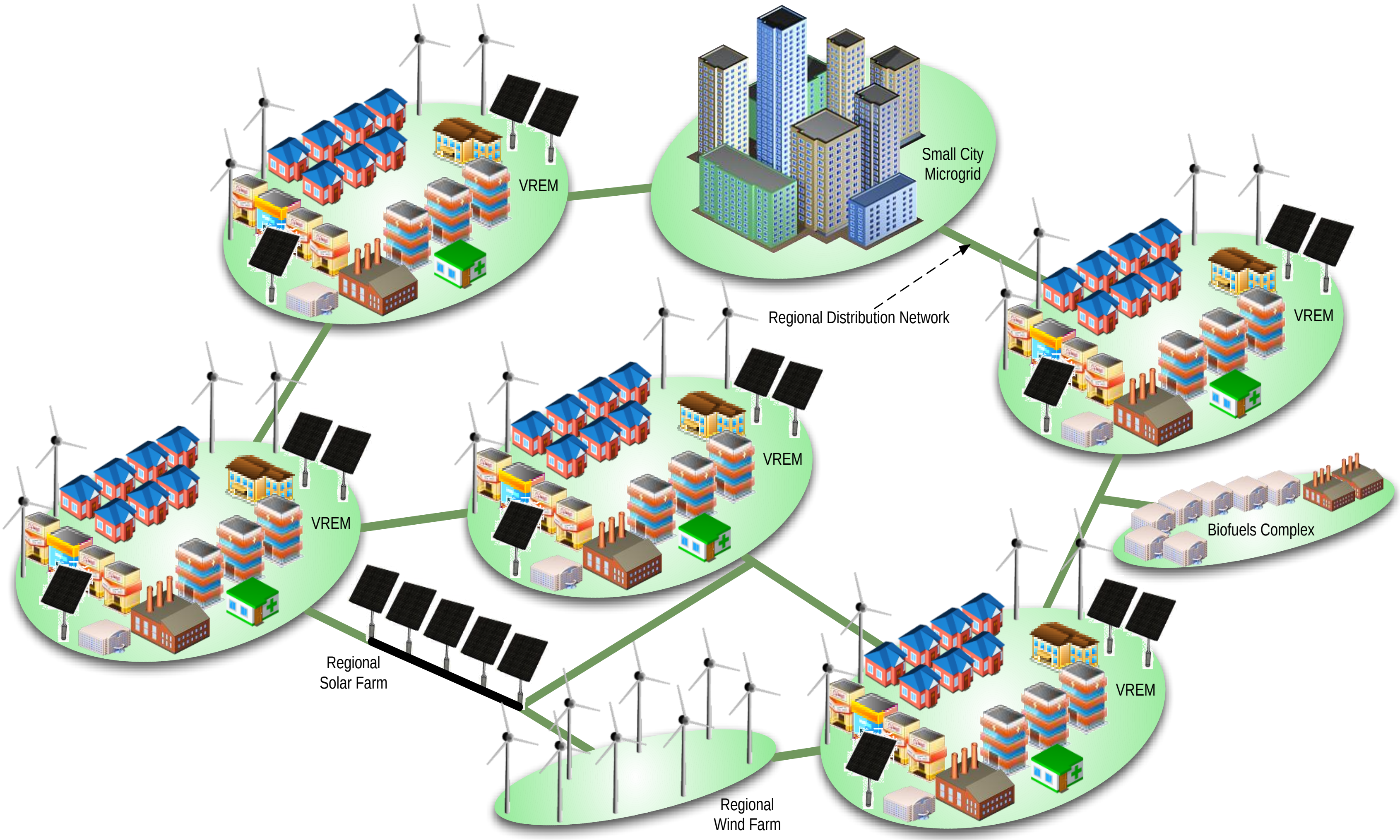
Uncertainties, Barriers and Risks

- **Technical:** Lack of appropriate technical operations requirements/decisionmaking models, insufficient communication and control infrastructure, lack of interoperability standards (aggregate/automate DER to meet system operator confidence);
- **Economic:** Business case for integration costs; incompatible market pricing structures, designing retail incentives to motivate sufficient response from DER to support grid needs;
- **Policy and Regulatory:** Moving from a centralized paradigm to combining decentralized elements and integrating DER; Electricity as a "Public Right";
- **Institutional:** Lack of Cost-Effectiveness and Valuation Methods; Interrelating wholesale with retail electricity markets, bridging organizational silos to achieve end to end solutions, down to end-use;
- **Customer Acceptance, Engagement and Differentiation.**

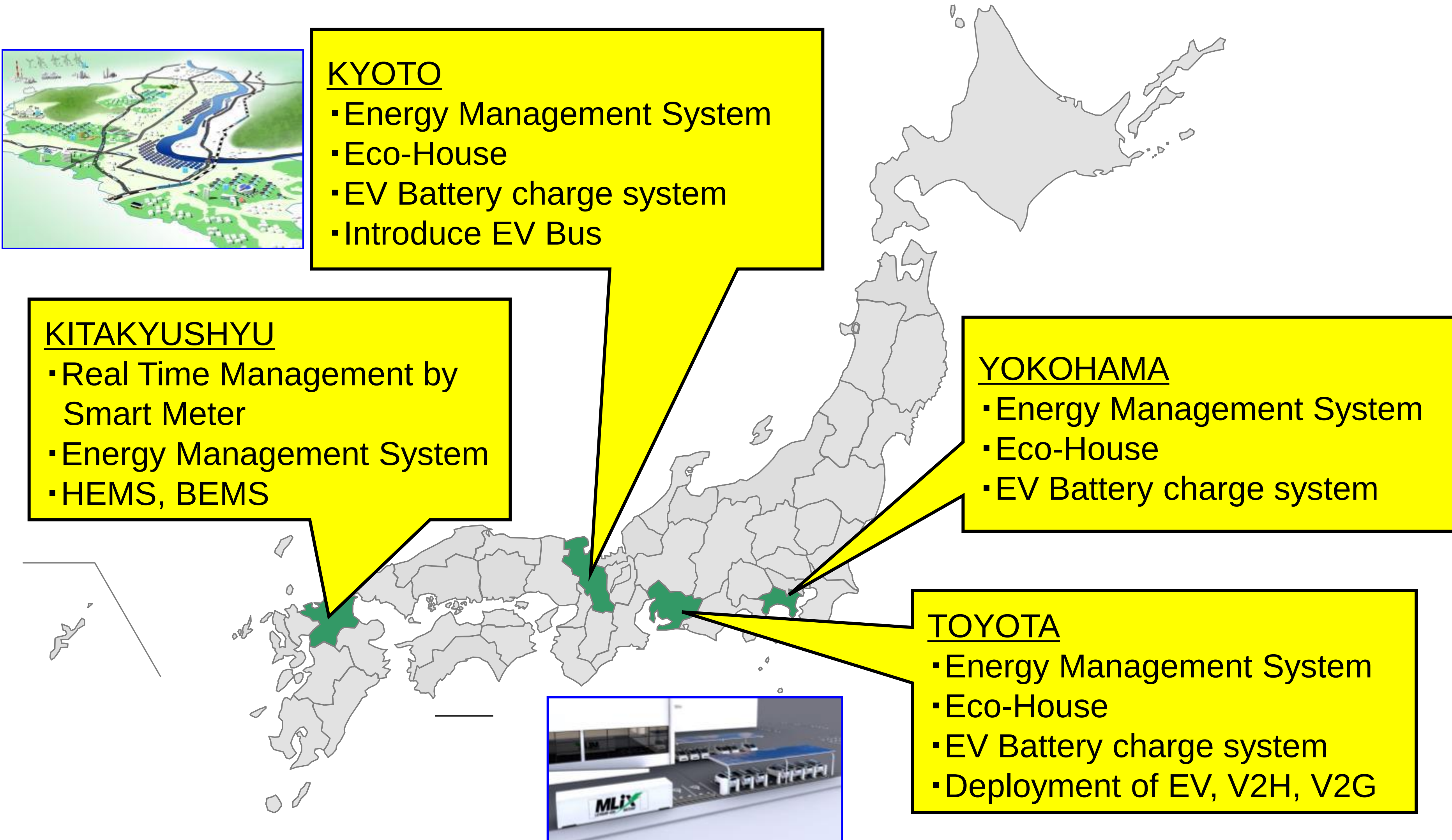
Demonstration Opportunity Areas

- **India's "Smart Cities Initiative":** Integrated Energy Systems Development;
- **India's Rural Electrification and Energy Access Programs:** Building upon "Mini-grid" installations with microgrid systems and networked microgrid cells across villages; more holistic approach to rural electrification that interrelates with India's grid modernization efforts;
- **Building Public, Private Partnerships through Demonstrations;**
- **Microgrid Demonstrations:** Locally-based intelligent energy distribution systems that can leverage private investment to help utilities, customers and communities achieve much higher levels of electricity performance (efficiency, power quality, resiliency and reliability, resource adequacy, heterogeneous customer services, renewable energy integration and environmental quality), while protecting key community facilities/functions during grid outages and energy disruptions.

Interconnected Smart Districts

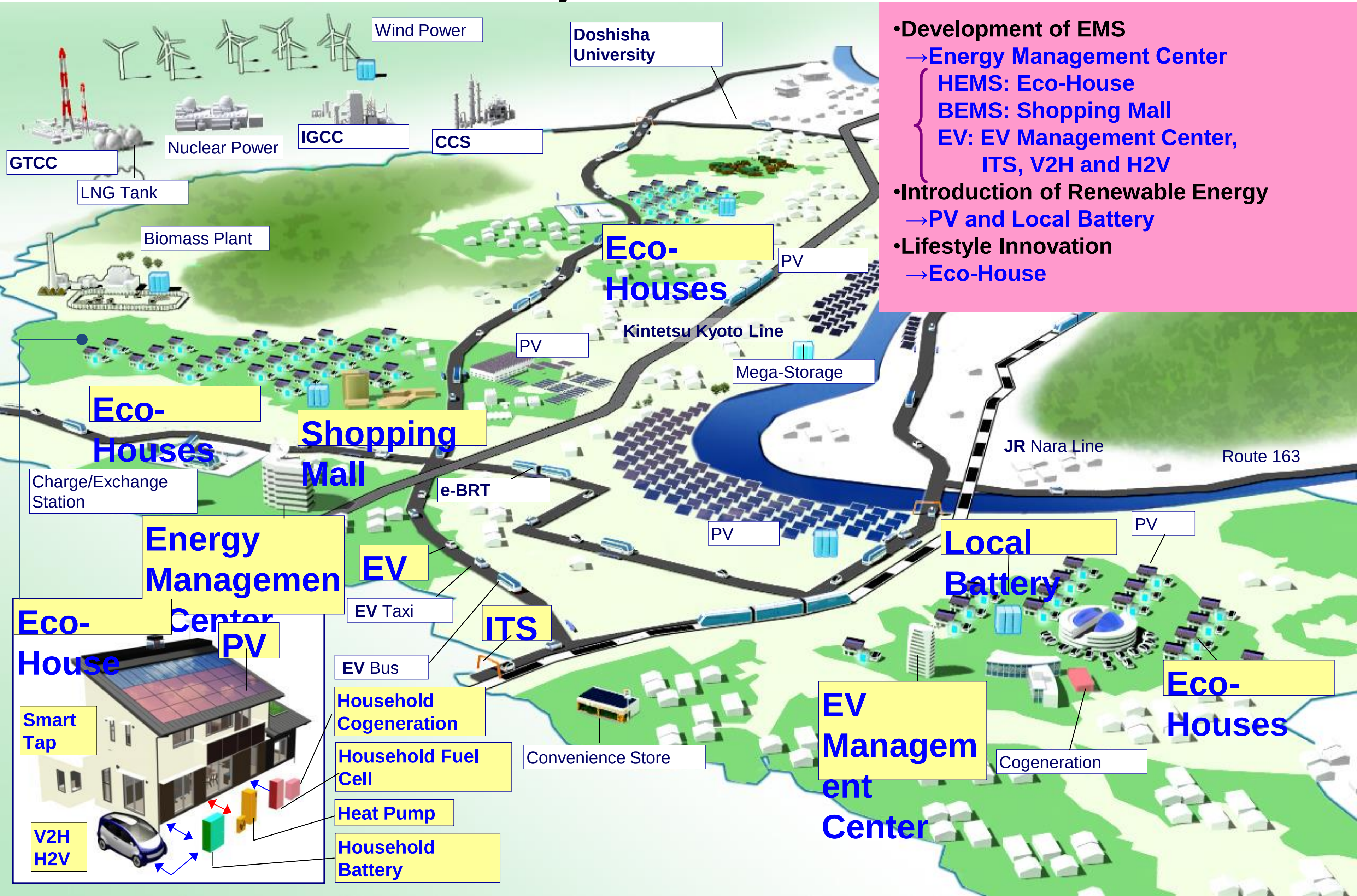


Smart Communities in Japan



*METI : Ministry of Economy, Trade and Industry in Japan

Kyoto



- **Development of EMS**
  - **→Energy Management Center**
    - **HEMS: Eco-House**
    - **BEMS: Shopping Mall**
    - **EV: EV Management Center, ITS, V2H and H2V**
- **Introduction of Renewable Energy**
  - **→PV and Local Battery**
- **Lifestyle Innovation**
  - **→Eco-House**

Thank You

General MicroGrids

Balancing Energy for a smarter, renewable-driven grid

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